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WEAR AND ELECTROCHEMICAL CORROSION BEHAVIOUR OF NANO ZRO_2 REINFORCED AA7075 METAL MATRIX COMPOSITES

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ABSTRACT

This article examine the corrosion and wear behavior of AA-7075 rein forced with Nano-ZrO_2, size of the particles varies from 20-30 nm and composites were fabricated by stir casting technique with wt% fraction varies from 0 to 4 wt%. The density of the base alloy and composites are measured. As per the ASTM standards Impact, strength and Compression strength were conducted. Microstructural study, Electrochemical corrosion, and wear test were conducted to assess the act of AA-7075 and composite. Nano-ZrO_2 is distributed uniformly, it was observed by metallurgical microscope. Wear is decreased at 2 and 4wt% of rein forcement. Coefficient of friction decreased for composites compared to the base alloy. Compressive and impact strength is developed in rein forcement from 0 to 4 wt%. Composites show a higher density Compared to AA-7075. It was observed at 4 wt% of composite have higher corrosion resistance with compared to AA-7075 in 3.5% NaCl solution.

***KEYWORDS**: Nano Zirconium Oxide, Corrosion, Wear Properties, Impact Strength & Compression Strength*

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Original Article

INTRODUCTION

During the last few decades, aluminum matrix composite materials are replacing the conventional engineering materials. There is a continuous interest among researchers to develop aluminum matrix composites with high strength to light weight, stiffness, good wear and corrosion resistance material for the structural applications, especially for aerospace and automobile engineering. Corrosion of metals is a destructive process regarding basic modern constructional materials with great importance for nowadays industry and in many cases represents an enormous economic loss. Overall cost and environmental implications of corrosion problems have become a major challenge to engineers in the fight against corrosion and the quest to reduce economic loss. Corrosion is one of the leading causes of structural damage and failure to engineering materials of particular importance is pitting and inter-granular corrosion, which can develop into fatigue cracks, stress corrosion cracks. Therefore, it is not a surprise that the research and several approaches on the corrosion and corrosion protection of metallic materials such as cathodic protection, coatings, and corrosion inhibitors have been developed on a large scale in different directions and a wide range of engineering decisions to mitigate corrosion [1].

M. Ramachandran et al. [2]: investigated that the corrosion behavior of Al-6061 reinforced with 2.5-7.5% weight nano-ZrO_2. He observed at 2.5-7.5% weight of nano-ZrO_2 composites lower corrosion rate compared to

Al-6061. In scanning electron microscopy images shows the average particle size of reinforcement and uniform distribution of reinforcement in Al-6061.

M. Sambathakumar et al. [3]: investigated the mechanical behavior of Al-7075 reinforced with SiC and TiC hybrid composites. In this investigation he found the density, corrosion resistance and microhardness of composites increased compared to base matrix, At 10 vol%, SiC+TiC shows better tensile strength increased 335 compared to Al-7075.

Govindan Karthikeyan et al. [4]: studied that the tribological properties of LM25/ZrO_2 composites. All wt. % ZrO_2 composites exhibit less wear compared LM25. Wear is higher at 10, 20 30 N for all the composites and LM25. When % ZrO_2 is increased in LM25 in such a case coefficient of friction decreased. At 30 N load shows a higher coefficient of friction compared to 10 and 20 N load. When the load is increased in such case wear in microns is gradually increased with time.

S.K. Nayak et al. [5]: investigated mechanical behavior of Al-ZrO_2-SiC and graphite hybrid metal matrix composites, At 2.75 vol% and 4.5 vol% of ZrO_2 composites show the 91.26 and 132.0 Mpa of tensile strength. Hardness is directly proportional to vol % ZrO_2. 103.7 is the greater hardness at 6 vol % of ZrO_2 composite.

METHODOLOGY

Materials and Fabricating Process

In the present work, the matrix material is used as AA-7075 alloy. Because it is high strength, low density, good wear resistance, and high thermal resistance material compared to different types of aluminum alloys. Zinc is the primary element in the 7000 series and universally used in many applications. Chemical composition of AA-7075 is shown in Table 1. AA-7075 was purchased from Venuka industries pvt Ltd, Medak, India.

Table 1: Chemical Composition of AA-7075

Si	Fe	Cu	Mg	Zn	Cr	Mn	Ti	Al
0.4	0.5	1.6	2.5	5.5	0.15	0.3	0.2	bal

Now a day's in MMCs ZrO_2 is the advanced material, in the present work Nano ZrO_2 was used as reinforcement material with a particle size of 20-30 nm from 0%, 2%, and 4% of its weight. Zirconia is one of the names for zirconium oxide. Most of the ZrO_2 having a monoclinic structure. Zirconium is useful at the time of crack propagation and high thermal expansion.

Table 2: Properties of Zirconium Oxide

Density	Melting Point	Elastic Modulus	Poisson's Ratio	Hardness No (HV_{30})
5.68(g/cm^3)	2800°C	220 GPa	0.3	900

Preparation of MMC

Nano zirconium oxide reinforced AA 7075 composite manufactured by stir casting methode in this work.

The matrix alloy was first superheated above its melting temperature in such a case the required quantities of reinforcement (2 and 4 Wt. %) particles were taken in containers. Then the nano-ZrO_2 was preheated to 450°C for 2 hrs. A furnace with a stirrer, pouring molten metal into mold and castings were shown in Figure.1. When AA-7075 was in a

liquid condition, stirring was started at 700 rpm speed in that time nano ZrO_2 particles are added into the molten metal by three steps. Less quantity of magnesium material was added to improving the wet ability between ZrO_2 and AA-7075. Argon gas was used as a degassi fire agent, after adding of ZrO_2 stirring continued for 5 min.

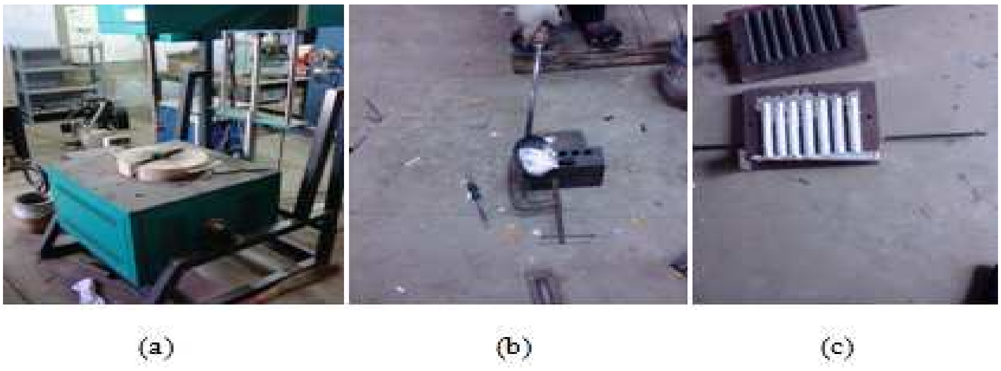


Figure 1: Shows the (A) Furnace with Stirrer (B) Pouring Molten Metal into Mold and (C) Castings

Density Studies

In many applications, density is an essential element to be treated. The density of AA-7075 and composites were measured with electronic specific gravity balancer, and with the help of rule of the mixtures theoretical density values are calculated.

Compression Test

The universal testing machine is used to withstand a load to reduce the size of the sample in a compression test. Dimensions cylindrical samples of 18 mm X 12 mm Φ (H/D=1.5) was machined from the extruded material as shown in Figure 2.

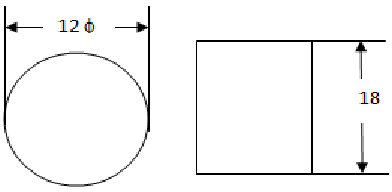


Figure 2: Dimensions of Compression Test Specimen

Impact Test

Impact test was carried out on the universal pendulum impact testing machine. The specimens for impact test are prepared on a horizontal shaper machine according to the ASTM E23 standard was selected to do the Charpy impact test and the sample is shown in Figure 3.

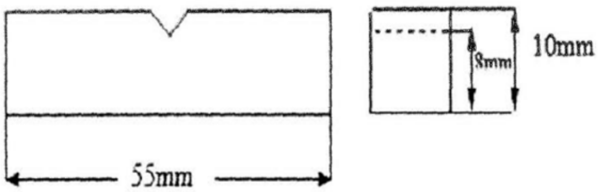


Figure 3: Dimensions Of Impact Test Sample

Wear Test

In this work, we used ASTM G99 pin on disc computerized wear test machine for doing the wear test. Disc of the material is steel. The disc surface was cleaned with high grade emery paper before testing. Figure.4 reveals the dimensions of the wear test samples were 8mm ϕ and 40mm length. In this wear test we used different types of parameters such as load is varied 10 to 30N, sliding velocity is 1.5 m/s, speed is 478 rpm, and sliding distance is 900 m. In the test pin was kept stationary perpendicular to the disc and disc was rotated.

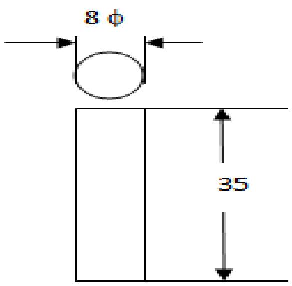


Figure 4: Dimensions of the Wear Test Sample

Electro Chemical Corrosion Test

AA-7075 and AA-7075/Nano ZrO_2 composites samples were cut with suitable dimensions and polished with 4 different grades of emery papers to obtaining the mirror polishing on the sample. 3.5% NaCl solution was used in this corrosion test for corrosion samples. During the test 0.1257 cm^2 of the sample was covered. In this corrosion test, we used three types of electrodes to calculate the electrochemical measurements. The working electrode is the first electrode it is under test with a specimen. Cathode or calomel electrode is the second one, and the platinum electrode was the third electrode. Calomel electrode was calculated corrosion potential (Ecorr) for 2 hrs time.

RESULTS AND DISCUSSIONS

Impact Test

The amount of energy absorbed by the material before the fracture is determined by standardizing Charpy impact test. Surabhi Lata et al. [6]: observed the impact strength increased at 5, 10 and 15% of TiO_2 composites compared to Al-5051. Jamaluddin Hindi et al. [7]: reported the mechanical properties of Al-6063 reinforced SiC composites, from the result impact strength initially increased at 2 and 4% of SiC composites than decreased at 6% SiC composite. When wt. % ZrO_2 increases automatically Impact strength is increased. Because of the reason ZrO_2 is distributed uniformly in all composites and good bonding of ZrO_2 in AA-7075 alloy. Figure 4, Figure 5 Shows the after testing impact specimens.

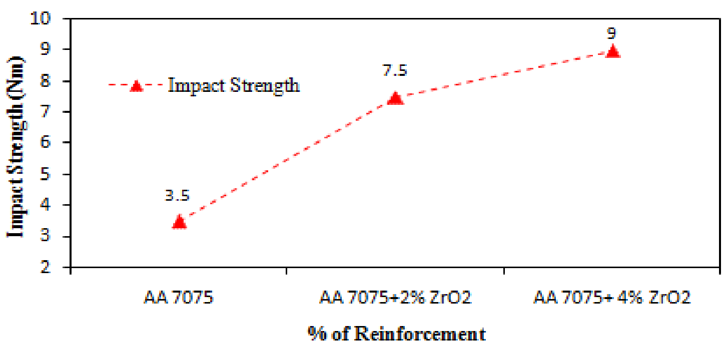


Figure 4: Graph Shows Impact Strength Vs % of Rein Forcement

Figure 5: After Testing Impact Test Specimens

Compression Strength and Density Studies

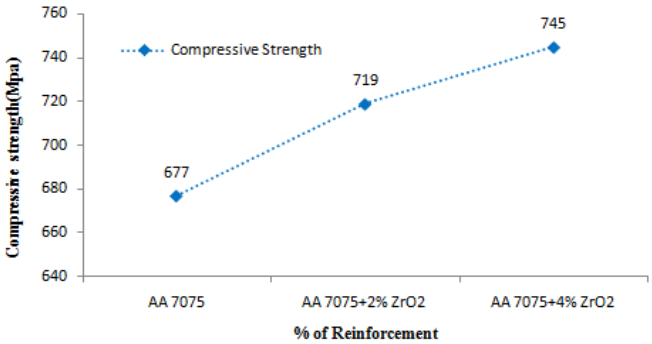


Figure 6: Graph Shows Compressive Strength Vs % of Reinforcement

Compression test was done by a universal testing machine, we apply max load on the specimen. When the crack is produced in the specimen at that results were noted for composites and base alloy. Among all the three variations of the composites, figure 6 shows the when wt. % ZrO_2 increases automatically compressive strength is also increased. Similarly Surabhi Lata et al.[6]observed when the TiO_2 wt% increased in AA 5051 in that time compressive strength increased.

According to Archimedes principle and rule of mixtures, average density values were determined, the variation in densitiess are graphical representation is given in Figure 8. Shows the density is increased at 2 and 4 wt% ZrO_2 reinforcement composites compared to base alloy due to the high density of ZrO_2. The above graph represents a comparison of theoretical densities and measured density.

(a) (b)

Figure 7: (a) Specimen in Compression Test, (b) Cracks in After Testing Compression Specimens

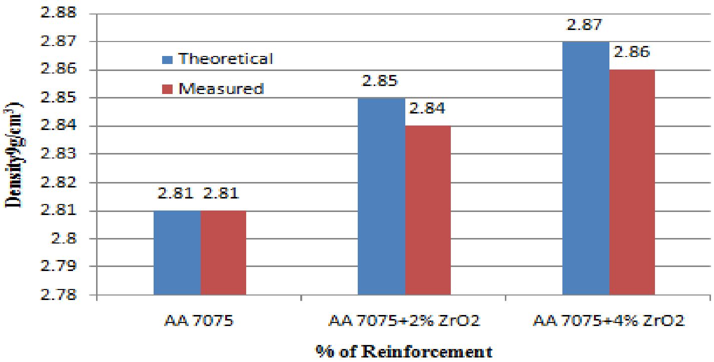


Figure 8: Graph Shows Density Vs % of Reinforcement

Wear Properties

Madhusudhan M et al.[8]: reported the wear behavior of AA-7075/ ZrO_2 composites. In Al-7075-8wt% ZrO_2 have high wear resistant, results indicate that quenching of heat treated specimens in water gives better wear resistance than that achieved by air, coefficient of friction of AA7075-ZrO_2 composites is higher than the Al-7075 matrix alloy. The pin on disc wear test was conducted to calculate the wear (microns) of various compositions of MMC. Figure. 9 shows the variation in the wear with variation in the weight percentage of the ZrO_2 reinforcements.

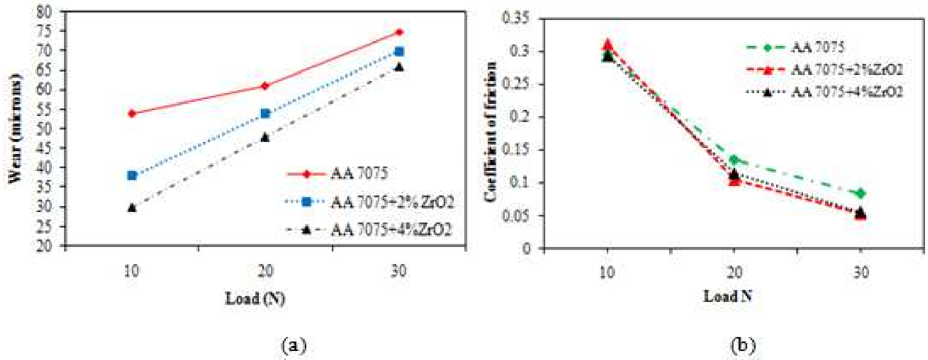


Figure 9: (a). Graph Shows Wear(M) Vs Load(N), (b) Coefficient of Friction Vs Load(N)

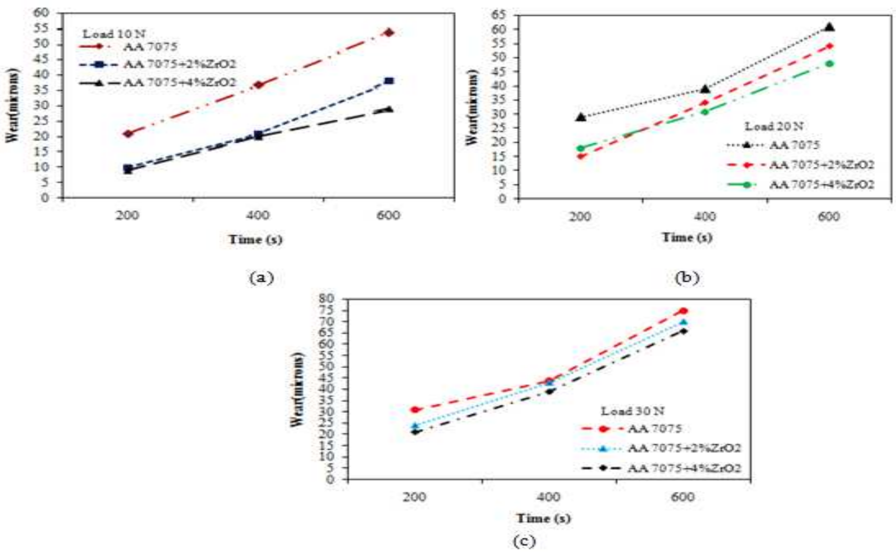


Figure 10: (a), (b) and (c). Graph Shows Wear(M) Vs Time(S) at 10, 20 And 30 N

At 478 rpmwith 1.5 m/s sliding velocity wear test was conducted at room temperature From the results compared to base alloy composites shows the low wear. Friction decreased with increasing wt% of reinforcement in the base alloy. S. K. Nayak et al. [5] : investigated wear behavior for Al-ZrO_2-SiC and graphite hybrid MMCs, at 7% SiC+1.75% graphite + 6% ZrO_2 shows the better coefficient of friction at all load conditions. At different sliding speed and time wear is increased. At 7% SiC+1.75% graphite + 4% ZrO_2 composite is better than the other two composites because it revealed better wear and friction.

Figure 10. show the wear loss in microns at various loads like 10, 20 and 30 N, when the load increased with time automatically wear increases at base alloy and composites. But compare to base alloy composites shows low wear in all load conditions.

Corrosion Studies

Joel Hemanth et al. [9]: studied that the corrosion behavior of 3-12 wt% of Nano ZrO_2 reinforced with LM-13(Al-Alloy)composites. From the results at 3, 6, 9 and 12 wt% of Nano ZrO_2 composites reveal the better corrosion resistance compared to LM-13 alloy due to the nano size of zirconia is presented in ZrO_2. 3.5% NaCl solution was used in this corrosion test for corrosion samples. During the test 0.1257 cm^2 area of the sample was covered. In this corrosion test, we used three types of electrodes to calculate the electrochemical measurements. The working electrode is the first electrode it is under test with a specimen. Cathode or calomel electrode is the second one, and the platinum electrode was the third electrode. Calomel electrode was calculated corrosion potential (Ecorr) for 2 hrs time. The potential at which current increases drastically was considered as critical potential (Ecorr). At 2 and 4 wt%, composite revealed better corrosion resistance (positive potential) compared to AA-7075.

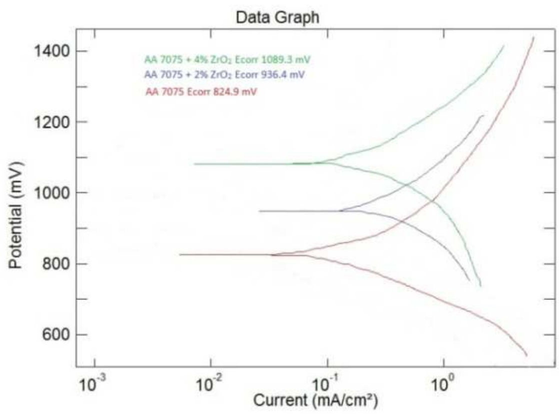
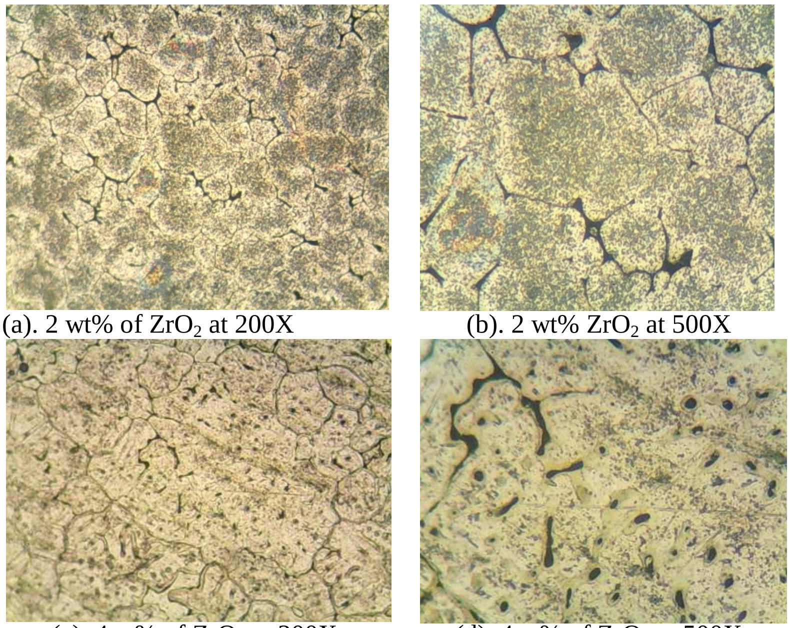


Figure 11: Polarization Curves of the AA 7075 Pure and Reinforced Composites In 3.5 % Nacl Solution

Microstructure Study

The metallurgical microscope was used to examine the microstructures at 200 and 500X. Before conducting the test the samples were polished four different grade polish papers. Figure 12 shows microstructure pictures. The images revealed good adhesive bonding and ZrO_2 is distributed uniformly in all composites. The microstructure images do not show Porosity and segregation in all wt%. ZrO_2 composites.



(a). 2 wt% of ZrO_2 at 200X (b). 2 wt% ZrO_2 at 500X

(c). 4wt% of ZrO_2 at 200X (d). 4wt% of ZrO_2 at 500X

Figure 12: Shows Microstructure Images of Composites at 200X and 500X

CONCLUSIONS

AA 7075 and composites were successfully fabricated by stir casting technique. From the experimental results it was observed, density is increased for 2 and 4 wt% ZrO_2 composites compared to the base alloy. At 2 and 4 wt% of ZrO_2 reinforced composites shows high impact strength compare to the base alloy. Due to brittleness specimens reveal the high compressive strength for ZrO_2 reinforced composites compares to base alloy. Corrosion resistance is increased at 2 and 4 wt% ZrO_2 reinforced composites due to proper bonding of ZrO_2 reinforcement in AA 7075 alloy. Microstructure study revealed ZrO_2 is distributed uniformly in all composites. At 2 and 4 wt. % ZrO_2 composite exhibits less wear compared AA-7075. Wear is higher at 10, 20 30 N for all the composites and AA-7075. When % ZrO_2 is increased in AA-7075 in such a case coefficient of friction decreased. At 30 N load shows a higher coefficient of friction compared to 10 and 20 N load. When the load is increased in such case wear in microns is gradually increased with time.

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